Introduction to Database Systems
CSE 414

Lecture 6: SQL Subqueries

Announcements

- HW2 and WQ2 released
  - Both due next Tuesday
- Please fill in the Azure questionnaire by tonight!
  - See HW2 writeup for details

Simple Aggregations

Five basic aggregate operations in SQL

```
select count(*) from Purchase
select sum(quantity) from Purchase
select avg(price) from Purchase
select max(quantity) from Purchase
select min(quantity) from Purchase
```

Except count, all aggregations apply to a single attribute

Everything in SELECT must be either a GROUP-BY attribute, or an aggregate

Need to be Careful…

```
SELECT product,
       max(quantity)
FROM   Purchase
GROUP  BY product
```

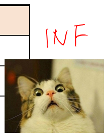
```
SELECT   product, quantity
FROM     Purchase
GROUP BY product
-- what does this mean?
```

Product	Price	Quantity
Bagel	3	20
Bagel	1.50	20
Banana	0.5	50
Banana	2	10
Banana	4	10

Product	Max(quantity)
Bagel	20
Banana	50

Product	Quantity
Bagel	20
Banana	??

INF



Semantics of SQL With Group-By

```
SELECT    S
FROM      R₁,…,Rₙ
WHERE     C1
GROUP BY  a₁,…,aₖ
HAVING    C2
```

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Evaluation steps:

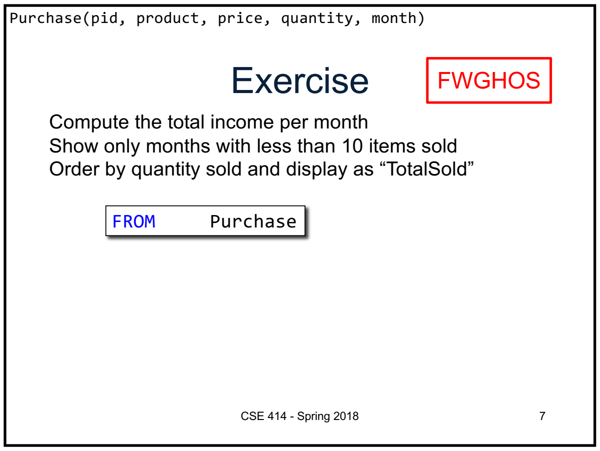
1. Evaluate FROM-WHERE using Nested Loop Semantics
2. Group by the attributes $a_1,\ldots,a_k$
3. Apply condition C2 to each group (may have aggregates)
4. Compute aggregates in S and return the result

```
Purchase(pid, product, price, quantity, month)
```

Exercise

FWGHOS

Compute the total income per month
Show only months with less than 10 items sold
Order by quantity sold and display as “TotalSold”



Purchase(pid, product, price, quantity, month)

Exercise

FWGHOS

Compute the total income per month
Show only months with less than 10 items sold
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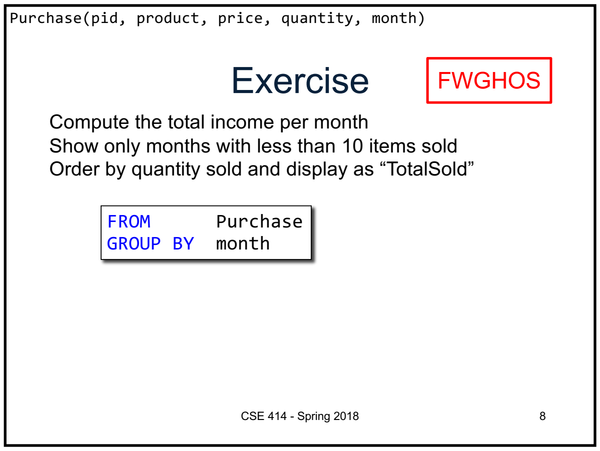
```
FROM      Purchase
```



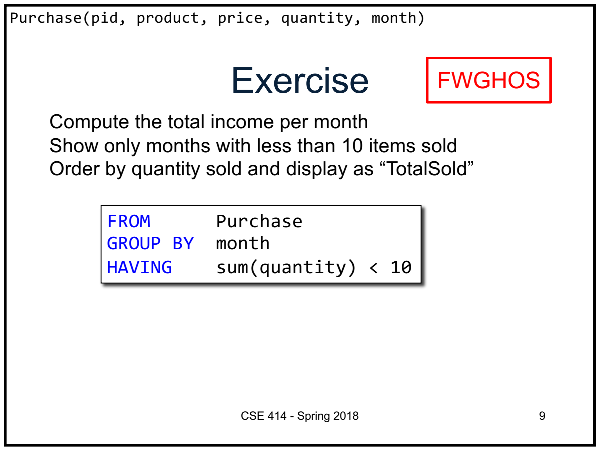
Purchase(pid, product, price, quantity, month)

Exercise

FWGHOS

Compute the total income per month
Show only months with less than 10 items sold
Order by quantity sold and display as “TotalSold”

```
FROM      Purchase
GROUP BY  month
```



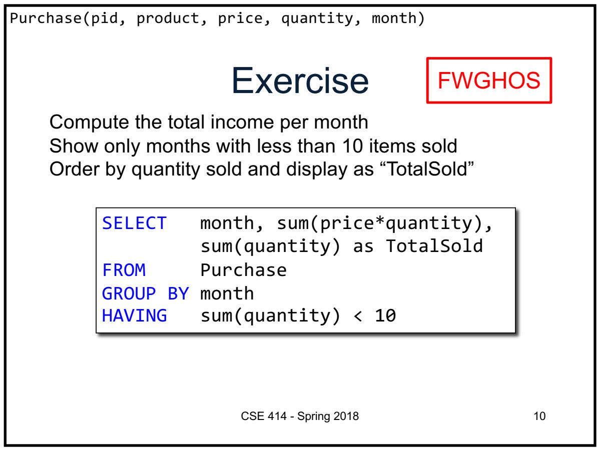
Purchase(pid, product, price, quantity, month)

Exercise

FWGHOS

Compute the total income per month
Show only months with less than 10 items sold
Order by quantity sold and display as “TotalSold”

```
FROM      Purchase
GROUP BY  month
HAVING    sum(quantity) < 10
```



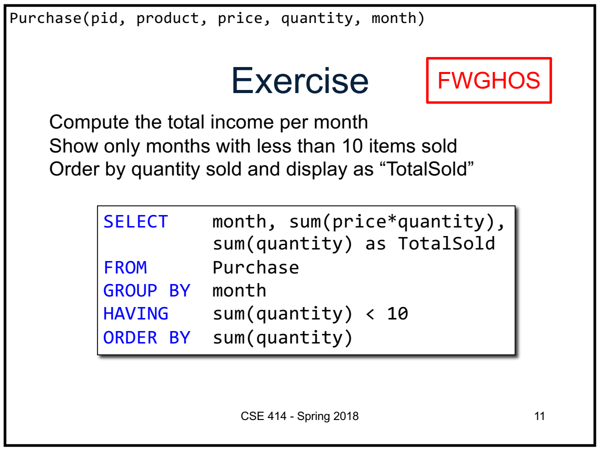
Purchase(pid, product, price, quantity, month)

Exercise

FWGHOS

Compute the total income per month
Show only months with less than 10 items sold
Order by quantity sold and display as “TotalSold”

```
SELECT    month, sum(price*quantity),
          sum(quantity) as TotalSold
FROM      Purchase
GROUP BY  month
HAVING    sum(quantity) < 10
```



Purchase(pid, product, price, quantity, month)

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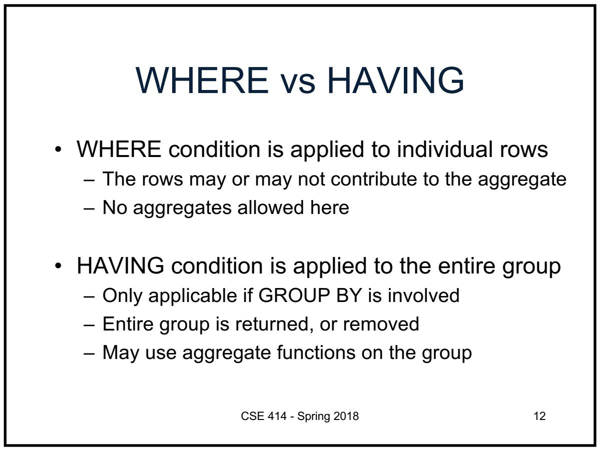
GROUP BY  month
HAVING    sum(quantity) < 10
ORDER BY  sum(quantity)
```



WHERE vs HAVING

- WHERE condition is applied to individual rows
  - The rows may or may not contribute to the aggregate
  - No aggregates allowed here
- HAVING condition is applied to the entire group
  - Only applicable if GROUP BY is involved
  - Entire group is returned, or removed
  - May use aggregate functions on the group

```
Product(pid,pname,manufacturer)
Purchase(id,product_id,price,month)
```

Aggregate + Join

For each manufacturer, compute how many products with price > $100 they sold

```
Product(pid,pname,manufacturer)
Purchase(id,product_id,price,month)
```

Aggregate + Join

For each manufacturer, compute how many products with price > $100 they sold

Problem: manufacturer is in Product, price is in Purchase...

```
Product(pid,pname,manufacturer)
Purchase(id,product_id,price,month)
```

Aggregate + Join

For each manufacturer, compute how many products with price > $100 they sold

Problem: manufacturer is in Product, price is in Purchase...

```
-- step 1: think about their join
SELECT ...
FROM Product x, Purchase y
WHERE x.pid = y.product_id
  and y.price > 100
```

manu facturer	...	price	...
Hitachi		150	
Canon		300	
Hitachi		180	

```
Product(pid,pname,manufacturer)
Purchase(id,product_id,price,month)
```

Aggregate + Join

For each manufacturer, compute how many products with price > $100 they sold

Problem: manufacturer is in Product, price is in Purchase...

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FROM Product x, Purchase y
WHERE x.pid = y.product_id
  and y.price > 100
```

manu facturer	...	price	...
Hitachi		150	
Canon		300	
Hitachi		180	

```
-- step 2: do the group-by on the join
SELECT x.manufacturer, count(*)
FROM Product x, Purchase y
WHERE x.pid = y.product_id
  and y.price > 100
GROUP BY  x.manufacturer
```

manu facturer	count(*)
Hitachi	2
Canon	1
...	

```
Product(pid,pname,manufacturer)
Purchase(id,product_id,price,month)
```

Aggregate + Join

Variant:
For each manufacturer, compute how many products with price > $100 they sold in each month

```
SELECT x.manufacturer, y.month, count(*)
FROM Product x, Purchase y
WHERE x.pid = y.product_id
  and y.price > 100
GROUP BY  x.manufacturer, y.month
```

manu facturer	month	count(*)
Hitachi	Jan	2
Hitachi	Feb	1
Canon	Jan	3
...		

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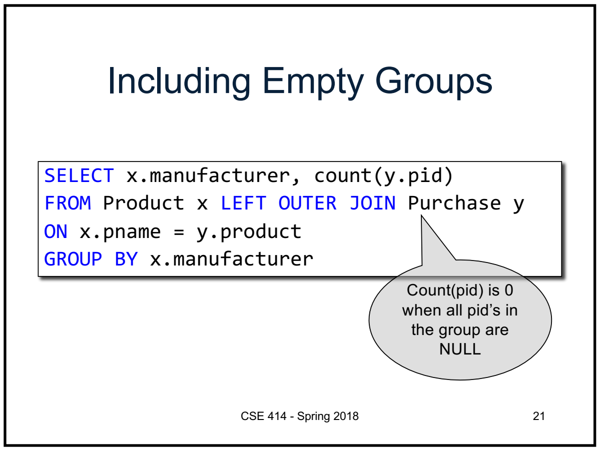
Including Empty Groups

- In the result of a group by query, there is one row per group in the result

Count(*) is never 0

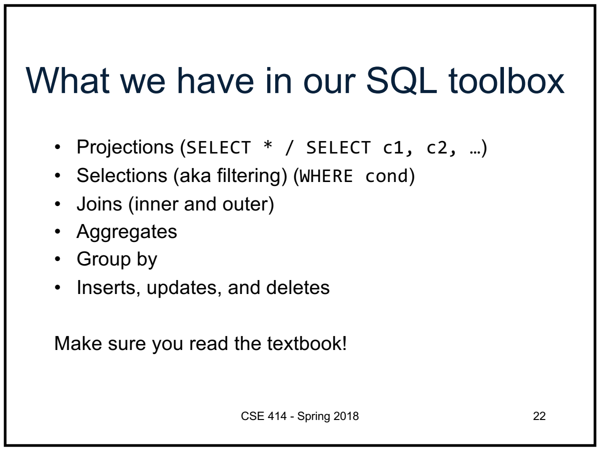
```
SELECT x.manufacturer, count(*)
FROM Product x, Purchase y
WHERE x.pname = y.product
GROUP BY x.manufacturer
```



Including Empty Groups

```
SELECT x.manufacturer, count(y.pid)
FROM Product x LEFT OUTER JOIN Purchase y
ON x.pname = y.product
GROUP BY x.manufacturer
```

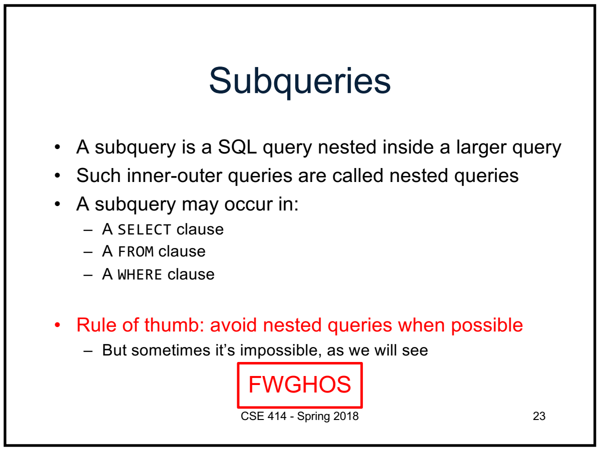
Count(pid) is 0 when all pid's in the group are NULL



What we have in our SQL toolbox

- Projections (`SELECT * / SELECT c1, c2, …`)
- Selections (aka filtering) (`WHERE cond`)
- Joins (inner and outer)
- Aggregates
- Group by
- Inserts, updates, and deletes

Make sure you read the textbook!



Subqueries

- A subquery is a SQL query nested inside a larger query
- Such inner-outer queries are called nested queries
- A subquery may occur in:
  - A SELECT clause
  - A FROM clause
  - A WHERE clause
- Rule of thumb: avoid nested queries when possible
  - But sometimes it's impossible, as we will see

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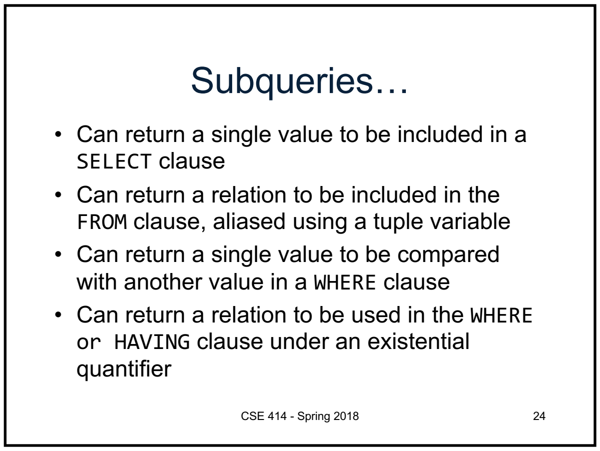
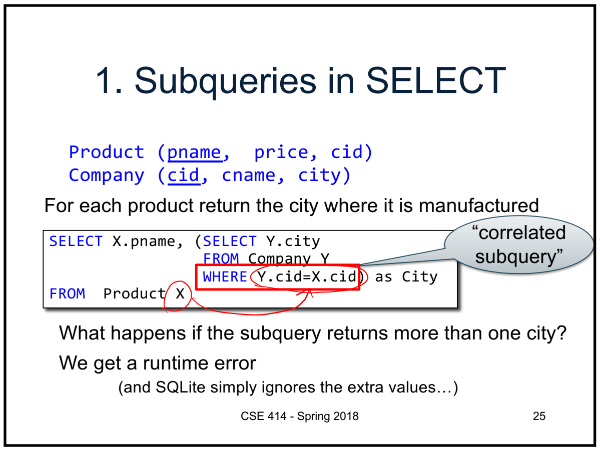


Subqueries…

- Can return a single value to be included in a SELECT clause
- Can return a relation to be included in the FROM clause, aliased using a tuple variable
- Can return a single value to be compared with another value in a WHERE clause
- Can return a relation to be used in the WHERE or HAVING clause under an existential quantifier



1. Subqueries in SELECT

```
Product (pname,  price, cid)
Company (cid, cname, city)
```

For each product return the city where it is manufactured

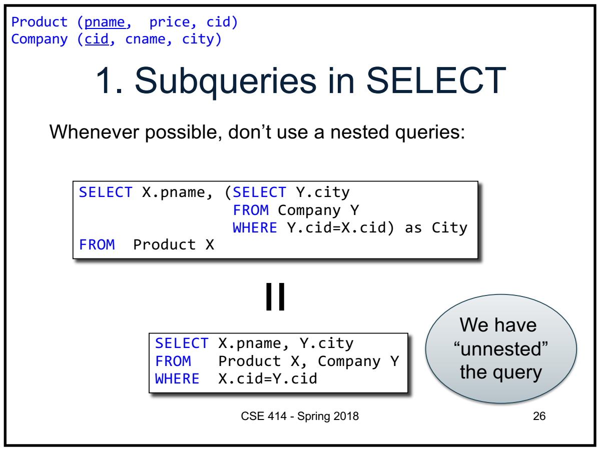
```
SELECT X.pname, (SELECT Y.city
                 FROM Company Y
                 WHERE Y.cid=X.cid) as City
FROM  Product X
```

"correlated subquery"

What happens if the subquery returns more than one city?

We get a runtime error

(and SQLite simply ignores the extra values…)



```
Product (pname,  price, cid)
Company (cid, cname, city)
```

1. Subqueries in SELECT

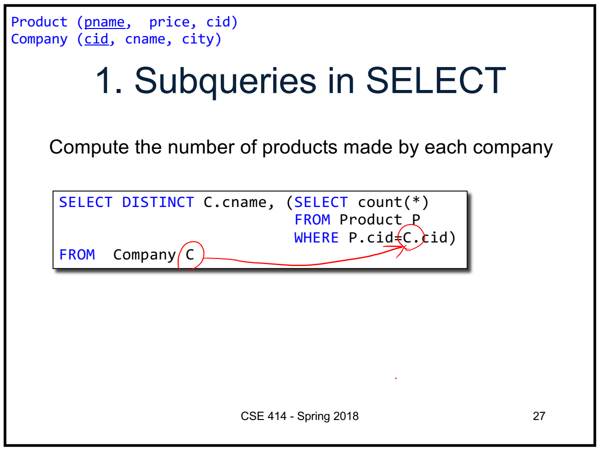
Whenever possible, don't use a nested queries:

```
SELECT X.pname, (SELECT Y.city
                 FROM Company Y
                 WHERE Y.cid=X.cid) as City
FROM  Product X
```

=

```
SELECT X.pname, Y.city
FROM   Product X, Company Y
WHERE  X.cid=Y.cid
```

We have "unnested" the query

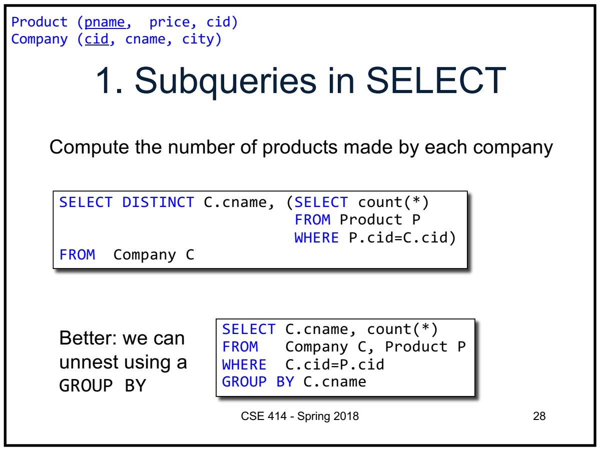


```
Product (pname,  price, cid)
Company (cid, cname, city)
```

1. Subqueries in SELECT

Compute the number of products made by each company

```
SELECT DISTINCT C.cname, (SELECT count(*)
                          FROM Product P
                          WHERE P.cid=C.cid)
FROM  Company C
```



```
Product (pname,  price, cid)
Company (cid, cname, city)
```

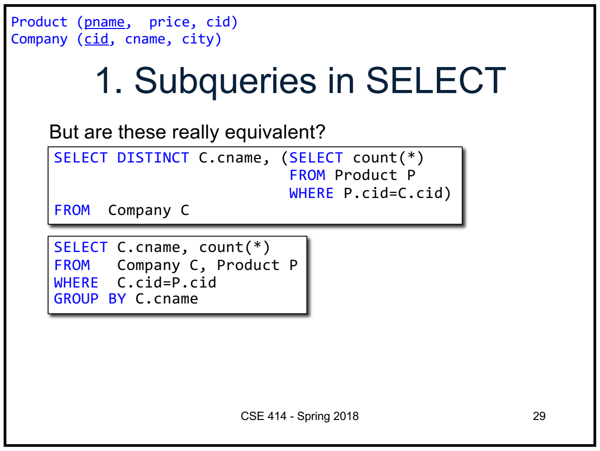
1. Subqueries in SELECT

Compute the number of products made by each company

```
SELECT DISTINCT C.cname, (SELECT count(*)
                          FROM Product P
                          WHERE P.cid=C.cid)
FROM  Company C
```

Better: we can unnest using a GROUP BY

```
SELECT C.cname, count(*)
FROM   Company C, Product P
WHERE  C.cid=P.cid
GROUP BY C.cname
```



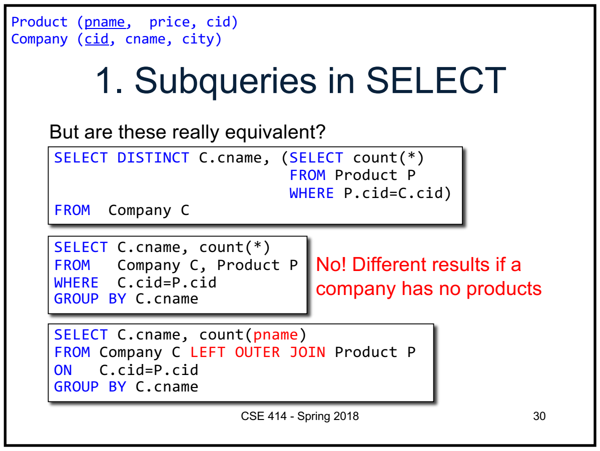
```
Product (pname,  price, cid)
Company (cid, cname, city)
```

1. Subqueries in SELECT

But are these really equivalent?

```
SELECT DISTINCT C.cname, (SELECT count(*)
                          FROM Product P
                          WHERE P.cid=C.cid)
FROM  Company C
```

```
SELECT C.cname, count(*)
FROM   Company C, Product P
WHERE  C.cid=P.cid
GROUP BY C.cname
```



```
Product (pname,  price, cid)
Company (cid, cname, city)
```

1. Subqueries in SELECT

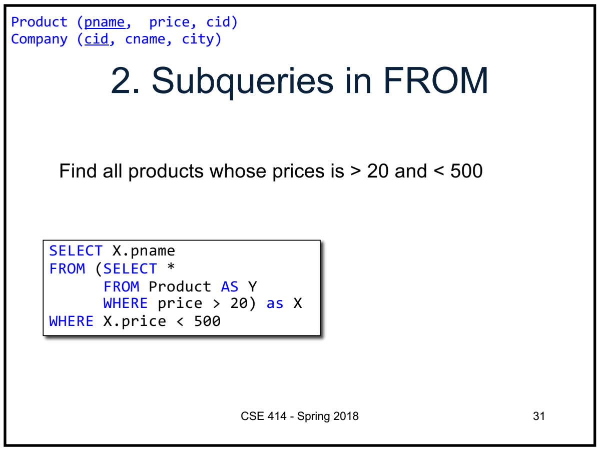
But are these really equivalent?

```
SELECT DISTINCT C.cname, (SELECT count(*)
                          FROM Product P
                          WHERE P.cid=C.cid)
FROM  Company C
```

```
SELECT C.cname, count(*)
FROM   Company C, Product P
WHERE  C.cid=P.cid
GROUP BY C.cname
```

No! Different results if a company has no products

```
SELECT C.cname, count(pname)
FROM Company C LEFT OUTER JOIN Product P
ON   C.cid=P.cid
GROUP BY C.cname
```

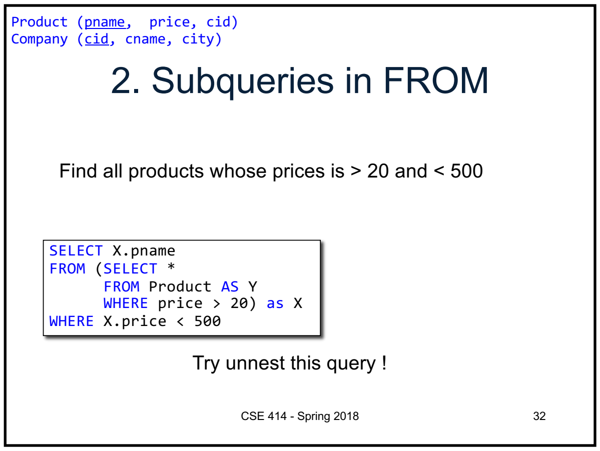


```
Product (pname,  price, cid)
Company (cid, cname, city)
```

2. Subqueries in FROM

Find all products whose prices is > 20 and < 500

```
SELECT X.pname
FROM (SELECT *
      FROM Product AS Y
      WHERE price > 20) as X
WHERE X.price < 500
```



```
Product (pname,  price, cid)
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2. Subqueries in FROM

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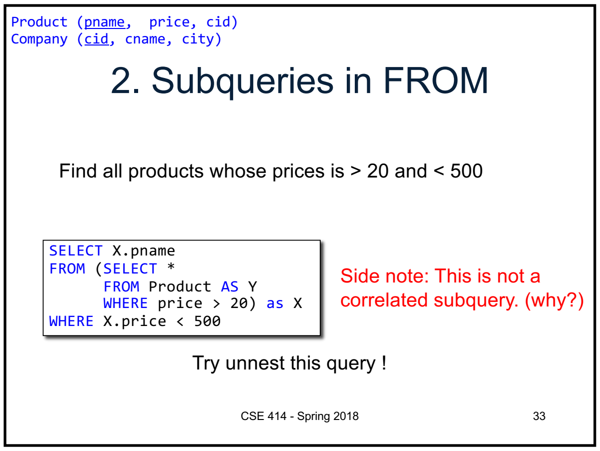
```

Try unnest this query !



```
Product (pname,  price, cid)
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2. Subqueries in FROM

Find all products whose prices is > 20 and < 500

```
SELECT X.pname
FROM (SELECT *
      FROM Product AS Y
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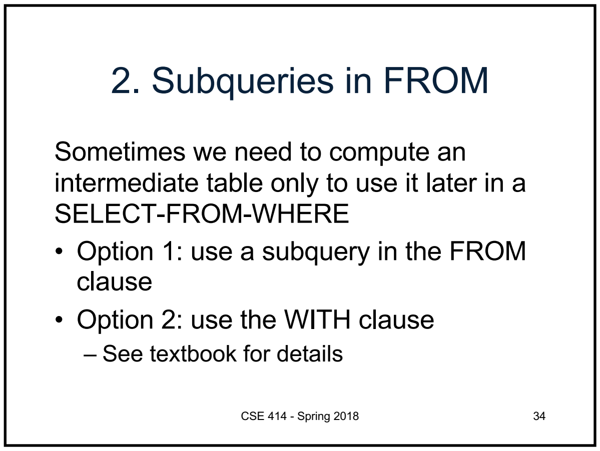
WHERE X.price < 500
```

Side note: This is not a correlated subquery. (why?)

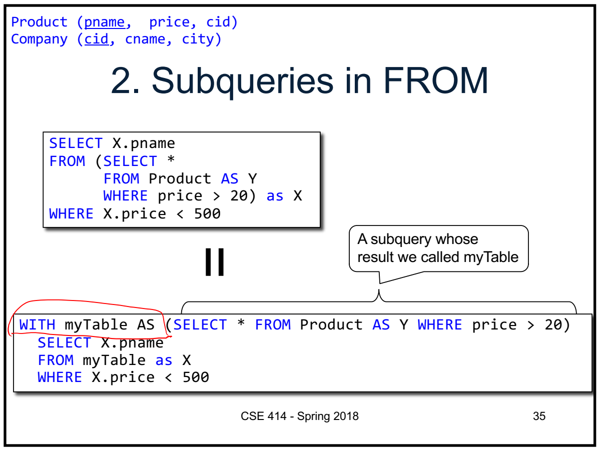
Try unnest this query !



2. Subqueries in FROM

Sometimes we need to compute an intermediate table only to use it later in a SELECT-FROM-WHERE

- Option 1: use a subquery in the FROM clause
- Option 2: use the WITH clause
  - See textbook for details



```
Product (pname,  price, cid)
Company (cid, cname, city)
```

2. Subqueries in FROM

```
SELECT X.pname
FROM (SELECT *
      FROM Product AS Y
      WHERE price > 20) as X
WHERE X.price < 500
```

||

A subquery whose result we called myTable

```
WITH myTable AS (SELECT * FROM Product AS Y WHERE price > 20)
  SELECT X.pname
  FROM myTable as X
  WHERE X.price < 500
```